Creating a dynamic impact zone for conflict prevention in real-time railway traffic management

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One way to deal with the growing need for reliable public transport, is to improve the accuracy of the trains in real-time. The accuracy starts with a robust timetable, capable of accounting for possible delays. However, in real-time, unexpected events, e.g., mechanical failures, can lead to primary and secondary delays. Once trains start deviating from their scheduled times, conflicts can occur. A conflict takes place when two trains want to reserve the same part of the infrastructure at the same time. These conflicts need to be resolved quickly in a way that the entire network is as least as possible disturbed. Therefore, the impact on the network should be taken into account when trying to prevent conflicts. In order to prevent conflicts, the Belgian railway infrastructure manager Infrabel has recently implemented a new Traffic Management System (TMS) that is capable of predicting train movements and detecting conflicts in real-time. However, a good conflict prevention module is not present for practical use yet ([1]; [2]). This paper introduces an approach to deliver good, feasible solutions for preventing conflicts in real-time. This approach tries to complete a Decision Support System (DSS) supporting dispatchers in making good decisions.

Every time a conflict is detected by TMS, it is immediately sent to the Conflict Prevention Strategy (CPS). If the conflict takes place in a station area, a solution based on rerouting is looked for first. The optimization module is based on a flexible job shop and is limited in calculation time in Cplex to 30 seconds. If the rerouting solution does not solve the conflict or if the conflict does not take place in a station area, a solution based on retiming/reordering one of the trains is given. Choosing which train to delay, implies considering what the impact on the rest of the network will be in the near future. On the one hand, all trains that could be impacted by the solution of the current conflict need to be taken into account when deciding on the current conflict. On the other hand, the computation time of the CPS needs to remain as low as possible for its usage in practice. Therefore, it is important to only consider the most relevant trains for the current conflict.

Offline calculations are carried out beforehand to examine which conflicts are *most likely* to occur in practice. These *most likely conflicts* are considered in our Dynamic Impact Zone (DIZ) heuristic. In this manner, a *dynamic impact zone* can be created by considering conflicts where one of the trains is in the current conflict, i.e. a *first order conflict*, and *most likely conflicts* with at least one of the trains in a *first order conflict*. Whenever a conflict needs to be prevented by delaying one of the trains, the progress of further movements is examined in both cases (delaying either one of the trains). During this progress, only trains relevant to the current conflict are considered. Relevant trains are trains in the *dynamic impact zone*. For more explanation on the methods used, we refer to [3].

The DIZ heuristic is tested on a large network: Brugge-Gent-Denderleeuw in Belgium. The simulation considers trains between 7 and 8 a.m., and includes in total 152 trains. A delay scenario assumes 60 % of all trains enter the study area with a delay randomly taken from an exponential distribution with an average of 3 minutes and maximum 15 minutes. The DIZ heuristic is compared to different dispatching strategies. The first strategy is First Come, First Served, resembling an unexperienced dispatcher. The second strategy considers all first-order conflicts. Table 1 shows results for 20 runs. Our DIZ heuristic clearly outperforms both FCFS and the first-order strategy, and at the same time has a rather low computation time. Whenever a conflict is sent to the CPS, it renders a feasible solution in 1 second on average. In 95 % of the cases the computation time of the CPS remains under the 2 seconds, which makes it very suitable for usage in practice.

Strategy	Total secondary delay	Average computation time
FCFS	774 min	0.02 s
First-order + rerouting	436 min (- 44 %)	0.9 s
DIZ + rerouting	252 min (- 67 %)	1 s

Table 1: Comparison of conflict prevention techniques based on total secondary delay and computation time.

References

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